19th Chaotic Modeling and Simulation International Conference

CHAOS 2026

12 - 15 Jun, 2026

Book of Abstracts

Venue: Hellenic Mediterranean University
Department of Management and Technology
Lakonia Campus
Agios Nikolaos, Crete, Greece

Contents

Preface

Dear Guests, Dear Colleagues,
We welcome you to the 19th Chaotic Modeling and Simulation International Conference -CHAOS 2026 in Agios Nikolaos.
As the previous years, a considerable number of high-quality research papers are accepted for oral or poster presentations.
Important speakers present onsite and virtually their work promoting scientific development and research.
We have submissions from 33 countries: Algérie, Austria, Belarus, Brasil, Bulgaria, Canada, Czech Republic, France, Greece, Hungary, India, Israel, Italy, Japan, Kazakhstan, Malta, Mexico, New Zealand, Nigeria, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, South korea, Spain, Sweden, Turkey, United Kingdom, Ukraine, USA, Uzbekistan.
I'd like to thank the Committees of the Conference which worked hard for this success.
I'd also like to thank the Region of Crete, our Sponsor.

Dr Christos H. Skiadas
ex- vice Rector
Technical University of Crete
Chair of ISAST

Plenary Talks

Isoscattering Non-Isospectral Quantum Graphs and Microwave Networks

Leszek Sirko, Omer Farooq[1], Michał Ławniczak[1], Szymon Bauch[1], Pavel Kurasov[2]

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Abstract
Isoscattering but non-isospectral quantum graphs are difficult to identify and complex to analyze. Failing to recognize their existence, however, will lead to an incorrect interpretation of the spectra. We use the Titchmarsh-Weyl M-function formalism to study different realizations of isoscattering, non-isospectral quantum graphs. The graphs that were analyzed possessed the same total length, but different topologies. The theoretical predictions are subjected to experimental verification using microwave networks.
Keywords: Quantum graphs, Microwave networks, Quantum and wave scattering, Isoscattering, Isospectrality, Dissipation.

What is a way to introduce a huge flux of energy in the initial onset of inflation?

i.e. Use of modified HUP and Torsion and a possible link to quantum number n meant to unify Black holes, and a quantum universe and its links to chaotic dynamics

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Abstract

First, We consider if a generalized HUP set greater than or equal to Planck's constant divided by the square of a scale factor as well as an inflation field, yield the result that Delta E times Delta t is embedded in a 5 dimensional field which is within a deterministic structure. Our proof ends with Delta t as of Planck time yielding an enormous potential energy**, Second, we tie this energy to black hole physics and the early universe. i.e ,**Our idea for black hole physics being used for GW generation , is using Torsion to form a cosmological constant. Planck sized black holes allow for a spin density term linked to Torsion.. We also outline how this process is chaotic , and its links to strange attractor physics, at the start of the generation of the early universe.

Turning Points, Tipping Points, and Regime Shifts: A Potential-Based Analysis of the Non-dissipative Lorenz Model, the Nonlinear Schrödinger Equation, and Energy-Balance Models

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Abstract

Based on our recent studies (Shen 2025a, b, c), we present a unified analysis of turning points in the non-dissipative Lorenz model, the nonlinear Schrödinger equation, and nonlinear energy-balance models (EBMs), and apply these insights to the study of tipping points and regime shifts central to

understanding climate transitions.

The study first introduces the Airy equation and the WKB approximation as mathematical tools for describing wave propagation and quantum tunneling near turning points, where solutions transition between oscillatory and exponential behavior. This analysis is then extended to the non-dissipative Lorenz model through its associated double-well potential, revealing a deep mathematical connection with the nonlinear Schrödinger equation. Together, these examples highlight the universality of second-order differential equations in governing turning-point dynamics, encompassing phenomena ranging from quantum tunneling to coherent solitary-wave structures in fluid and atmospheric systems.

The potential-function framework is then applied to nonlinear EBMs to interpret tipping points and regime shifts. In this context, tipping behavior is associated with changes in the sign of the curvature of the potential function, making transitions between stable and unstable states. Building on classical bifurcation theory, a tipping process is defined as a coupled evolution involving (1) a bifurcation—corresponding to the merging or disappearance of equilibria—and (2) a transition between stable and unstable states. Using geometric analysis of the potential function, bifurcations are identified at points where both the first and second derivatives vanish, corresponding to the coalescence of extrema at an inflection point, accompanied by the loss of stability. Three representative EBMs, exhibiting tipping or non-tipping behavior, are analyzed, demonstrating that systems undergoing tipping may transition to either stable or unstable states.

Comparisons with the non-dissipative Lorenz model reveal that forced, dissipative regime shifts and conservative turning-point dynamics share analogous barrier-crossing structures in potential landscapes. Finally, tipping-induced regime shifts in EBMs are compared with regime transitions in the Lorenz (1976) cubic map, emphasizing the role of almost-intransitivity (Shen 2023, 2025a). Overall, the proposed classification clarifies the mechanisms underlying nonlinear transitions and provides

a rigorous foundation for interpreting predictability and regime change in climate and other complex systems.
Keywords: turning points; tipping points; regime shifts; non-dissipative Lorenz model; nonlinear Schrodinger equation; energy-balance models; bifurcation; almost-intransitivity

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From Homogeneity to Multifractality in the Galaxy Distribution

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Abstract

We have recently argued that a simple nonlinear law could be important for the origin of the Universe, resulting in fractal and multifractal features [1]. As revealed by space missions in the local space environment, the fractal structures in nature appear to exhibit universal properties [2]. Therefore, we have applied a similar method to determine a reliable multifractal spectrum of the galaxy distribution on cosmological scales, based on observations of nearly one million of galaxies in the Updated (2008) CfA Redshift Catalog. We demonstrate that the observed spectrum is consistent with weighted one- or two-scale Cantor set models, in which the entire space is visited with varying probabilities [3], a feature characteristic of laboratory turbulence and space-_lling turbulence inside the Sun's heliosphere immersed in the very local interstellar medium, cf. [2]. However, the degree of multifractality for galaxies is smaller than that found inside the heliosphere and exhibits variations between nearby and more distant galaxies [3]. A possible asymmetry of the spectrum may be related to the presence of voids in the large-scale matter distribution and to deviations from Hubble's law for an idealized spuniform expansion [3,4]. Here, we

show that the deviations from homogeneity revealed by multifractal analysis should be broadly consistent with _CDM large-scale structure formation, even for distant galaxies receding from the Solar System at ultra-relativistic velocities.

Keywords: scaling: multifractals; universe; galaxies: clustering; mass distribution.

Acknowledgments. This work has been supported by the National Science Centre, Poland (NCN), through grant No. 2021/41/B/ST10/00823.

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Special Sessions

Title: Complex Nonlinear Dynamics toward Chaotic Supremacy

Organizers

Fumiyoshi Kuwashima[1] Takashi Isoshima[2]

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Description:

The proposed Special Session aims at presenting an overview of ways toward Chaotic Supremacy through recent fundamental and applicational progresses on complex nonlinear and chaotic dynamics. Chaotic Supremacy is a new concept to express the properties and functions that can be realized only by chaos. It has been firstly proposed based on the finding of fast convergence in Chaotic Monte Carlo simulation, that is as fast as the quantum Grover algorithm. Such supremacy originates from various features of chaos, such as ergodicity, mixture property, and structural stability.

The Special Session is composed of five talks, starting with experimental and theoretical research on laser chaos for stable generation of terahertz (THz) wave, and then a study on THz gyrotrons, an optical bistable device with time-delayed refractory feedback for chaotic network, analysis on controllability of dynamical properties of time-delayed feedback system, and finally a novel approach in deep learning for prediction of chaotic dynamics.

We arrange this session to promote discussion between researchers in the field of nonlinear dynamics, laser and THz waves dynamics, nonlinear optics, delayed feedback system, and machine learning for prediction of complex dynamics, and moreover to stimulate further studies in these research fields.

Complete list of speakers:

1. Fumiyoshi Kuwashima (Otemon Gakuin University Japan): “Creation of New Features using Chaos -Highly Efficient THz Wave using Chaotic Supremacy -”
2. Masafumi Fukunari (University of Fukui, Japan): “Recent Advances in the Design and Applications of High-Power Terahertz Gyrotrons”
3. Takashi Isoshima (RIKEN, Japan): “Geometrical Control of Functional Node in Two-dimensional Optical Bistable Device toward Chaotic Network”
4. Zhongxi Zhang (Fukuoka Institute of Technology, Japan): “Controllability of Chaotic Properties under Spectral Constraints in Generalized Boole Transform”
5. Taira Tsunekawa (Kyoto University, Japan): “Forecasting Noisy Chaotic Dynamics: A Robust Deep Learning Approach”

Title: Accounting and Financial Management

Chair: Christos Floros

Laboratory of Accounting and Financial Management- LAFIM of Hellenic Mediterranean University

The papers of the Session

Determinants of Audit Fees in the UK and the USA

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2Department of Management Science and Technology, Hellenic Mediterranean University, Crete, Greece.

Abstract
This study provides additional evidence on the factors influencing audit fees paid by listed companies in the UK and US. The main aim of this study is to develop a clearer understanding of how the audit market operates. Key determinants include client size, return on shareholders' equity, number of subsidiaries, the time lag between financial year-end and the audit report date, auditor size, the extent of client diversification, ownership structure, firm risk etc. Using a regression analysis, we report that audit fees depend on firm size and risk.
Keywords: Audit fees, regression analysis, US, UK.

Performance budgeting as a tool of monitoring and improving Public Sector's Administration: The case of Greece

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Abstract
As the Global economy has recovered from the recent crisis of COVID – 19 pandemic, but also continuously faces challenges due to geopolitical instability, with serious consequences in the energy supply and fluctuations in the commodities and currency trade, public administration struggles to maintain a sustainable level of performance in order to adhere. A performance budgeting system is considered as a significant tool for maintaining sustainable levels of fiscal performance. It is based on the introduction of a coherent framework for assessing performance, through target setting and indicators to measure the degree of achievement of the target. The development and successful implementation of such a framework is a major challenge on the reform, which evolves in many countries' public sector. Moreover, in the new emerging reality, where climate change has significant socio-economic impacts, which must be taken into account when making decisions on the choice of financing for fiscal policies, the assessment and inclusion of the environmental impact of the funded policies is considered particularly critical. Greece is one of the countries, which has "answered that call" and especially during the last four years (2021-2025), has given crucial attention on the association of its target setting and monitoring, with the results analyzed through the tool of performance budgeting. In the current study, we investigate the relationship of significant components and key performance indicators in general government bodies and ministries, with the fiscal policy

decision making. *Keywords:* Performance budget, fiscal policy, economic crises, environmental impact.

The effect of ECB's non-conventional measures on bank lending: Evidence from covid-19 pandemic period

Nikolaos Petrakis[1a], Christos Lemonakis[1b], and Christos Floros[2]

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Abstract
The outbreak of the COVID-19 pandemic negatively affected euro area economies, capital and funding markets. In response to this pervasive crisis the ECB introduced new unconventional pandemic measures in order to support bank credit and economic activity. The aim of this study is to explore how the new non-standard measures implemented by the ECB during the pandemic affect bank lending to the private sector, compared to previous periods of implementation of these measures. To investigate this topic, we use advanced panel data regression methodology and process monthly loan data for 15 euro area countries from January 2007 to December 2021. The main findings of our analysis reveal that, during the sampling period, in general, ECB's unconventional measures support bank credit to private sector. The outbreak of covid-19 crisis had a significant negative effect on bank credit while new non-conventional pandemic measures improved credit provision to private corporations. Keywords: Unconventional monetary policy measures, Covid-19 crisis, Panel data.

Interdependencies across cryptocurrency sectors: New evidence from DCC-GARCH R2 decomposed connectedness measures

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Abstract
In this study, we employ the recently developed R2 decomposed connectedness approach of Cocca et al. (2024) to estimate time-varying interdependencies among Bitcoin (BTC), Ether (ETH), Solana (SOL), Uniswap (UNI), Polkadot (DOT), and Monero (XMR). The sample spans from October 4, 2020, to August 14, 2025, thereby capturing major structural and cyclical developments in the cryptocurrency ecosystem. BTC serves as the dominant market benchmark and primary sentiment driver, while ETH represents the backbone of smart contract applications. SOL acts as a high performance competitor in the smart contract space; UNI functions as a governance token within decentralized finance; DOT facilitates blockchain interoperability; and XMR remains the leading privacy-focused cryptocurrency. Together, these assets represent heterogeneous functional segments of the crypto market. Our empirical findings reveal significantly positive and strongly time-varying co movements across all cryptocurrencies. On average, up to approximately 80% of the dynamics of major assets such as BTC and ETH can be explained by the system-wide network, whereas XMR exhibits substantially lower explainability of roughly 40%, indicating relative segmentation. We further document that interdependencies intensify around major economic and crypto-specific events. The net total directional

connectedness measures show that ETH, DOT, and BTC act as the primary transmitters of contemporaneous shocks. In contrast, XMR and SOL emerge as dominant net receivers. The time-varying dynamics indicate substantial regime shifts: SOL exhibits strong net receiving behavior in 2021, while XMR becomes a pronounced receiver in 2022 and again from 2024 onward. ETH and DOT persistently function as net shock transmitters throughout the sample, whereas BTC's transmission role peaks during 2022. Finally, our multivariate optimal portfolio analysis demonstrates economically meaningful diversification benefits. Except for BTC in the minimum-variance framework and ETH in minimum-correlation and connectedness-based portfolios, all assets contribute to substantial portfolio risk reduction. Overall, our results provide important implications for portfolio allocation, hedging design, and systemic risk monitoring in cryptocurrency markets.

A Hybrid Bayesian Framework for Analysing a Bank's Decision-Making Under Uncertainty

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This paper presents a novel hybrid Bayesian framework that connects macro-level economic and political dynamics with a microeconomic model of a bank's decision-making. The methodology integrates an Adaptive Hierarchical Panel Vector Autoregression (BVAR) and a Bayesian Belief Network (BBN) to generate probabilistic forecasts of key economic variables and policy outcomes. These forecasts are then used to inform the parameters of a microeconomic model of a bank's behaviour under uncertainty, which is a structural model of economic theory. This approach provides a multi-level, data-driven analysis that accounts for the complex interplay of

macroeconomic forces, political decisions related to the low-carbon transition, and a bank's utility-maximising behaviour

Transfer Pricing as Financing Tool and Specific Issues that Arise

Ioannis Aggelakis

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Abstract

This study examines how, in the context of intensified globalization, intragroup pricing, commonly referred to as transfer pricing, functions as a structural tool of internal financing. In particular, it focuses on the way multinational enterprises determine internal interest rates, service fees, and royalties for cross-border intragroup transactions. These mechanisms enable corporate groups to allocate capital dynamically and transfer liquidity from subsidiaries with high cash reserves to subsidiaries facing capital constraints, while also optimizing the overall tax burden and reducing the total cost of debt. The study analyses the strategic mechanisms through which transfer pricing is used for internal financing. Since such transactions take place across different tax jurisdictions, their use as financing instruments requires strict compliance with international tax regulations. At the same time, the transfer pricing mechanisms adopted by multinational enterprises have become increasingly complex, creating significant challenges for tax authorities worldwide. The study therefore examines the current frameworks used by tax administrations to assess and control intragroup transactions, with particular emphasis on the arm’s length principle, documentation requirements, and enforcement mechanisms. Given the intensity of regulatory scrutiny in this area, multinational enterprises commonly rely on specialized tax departments or operational transfer pricing software to continuously monitor, model, and document intercompany

financing arrangements. Finally, the study provides a comparative analysis of international tax regulations in order to identify key areas in which existing control mechanisms may be insufficient, inconsistent, or difficult to apply effectively.

JEL Classification: M41 Accounting
Keywords: Intra group transactions, Financing Tool, Taxation

Invited Talks

Nonlinear dynamics of a simple behavioral model of inflation

Anna Agliari, Fernando Bignami, Nicolò Pecora

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Abstract
In this work we analyze the dynamics of a behavioral model of inflation with heterogeneous agents, along the lines of Cornea et al. (2019). Agents, albeit knowing the economic fundamentals, and thus being able to derive a fundamental value of inflation, create beliefs about what the deviation of actual inflation from this fundamental path will be in the next period. In particular, we consider two versions of the model by including different types of linear expectations, namely mean reverting, trend extrapolating and anchoring and adjusting rules. Agents are also allowed to switch between these different forecasting strategies based on their recent relative forecasting performance. We investigate the local stability of the fundamental steady state and analytically show the possible occurrence of a degenerate Neimark-Sacker bifurcation. Moreover, the global analysis of the model highlights the coexistence of different attractors associated with a subcritical Neimark-Sacker bifurcation which, in turn, takes place as the effect of an increase of the trend extrapolating forces.
Keywords: Neimark-Sacker; Chenciner bifurcation; Closed invariant curves; Heterogeneous expectations; Inflation.

Interpretable chaotic time series forecasting using a Type-2 fuzzy inference

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Abstract

Forecasting chaotic time series remains a challenging task due to the nonlinear and unpredictable nature of the underlying systems. This study proposes a forecasting methodology based on a Type-2 Fuzzy Inference System (FIS), optimized using the Particle Swarm Optimization (PSO) algorithm. The Mackey–Glass chaotic equation is employed as a case study, simulated over 1200 samples to generate training and validation data. The prediction process uses four previous time series values to estimate the next one, providing a framework for short-term forecasting of nonlinear dynamics.

The developed FIS follows the Sugeno structure, with three Membership Functions (MFs) assigned to each input variable. The training process is divided into three stages: (1) learning the fuzzy rule base, (2) tuning the parameters of the upper MFs and the output functions, and (3) optimizing the lower MFs to introduce the Footprint of Uncertainty (FOU), which distinguishes Type-2 systems from conventional Type-1 models. The progressive reduction in Root Mean Square Error (RMSE) across these stages demonstrates a consistent improvement in prediction accuracy.

Beyond its predictive performance, the proposed model maintains a **high degree of interpretability** through its fuzzy rule base. These rules provide transparent, human-understandable mappings between input and output variables, enabling insight into the system's decision-making process — a key advantage over black-box models such as neural networks. The results show that Type-2 FIS models effectively balance computational accuracy and interpretability, offering a robust and flexible approach for modeling and forecasting chaotic and nonlinear phenomena.

Keywords: Type-2 fuzzy inference system; chaotic time series; interpretability; Mackey–Glass equation; particle swarm optimization; uncertainty modeling.

Stochastic Balance Laws Perturbed by Levy Noise and the Malliavin Calculus

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Abstract: In this work we consider the stochastic conservation laws perturbed by Lévy noise. We propose a generalized of the Kruzkov entropy condition by allowing the Kruzkov constants to be Malliavin differentiable random variables. We establish the existence and uniqueness of the entropy solution.

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Keywords: Lévy noise, Conservation laws , Malliavin differentiable random variables, Entropy solution

Chaos as the Key: Unlocking Selectiveairborne Microparticle Transport

Philippe Beltrame, Pierre Trontin

Use of Multi-factor Modeling to Determine the Parameters for Rational Composite Support in Difficult Mining-geological Conditions

Volodymyr Bondarenko, Maksym Shyshov, Iryna Kovalevska, Viktor Pochepov & Ivan Sheka

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Abstract

The paper determines the rational parameters for composite support in difficult mining-geological conditions of mines using Chaotic Modeling. The conducted computational experiment was based on three-dimensional modeling of the geomechanical system of a preparatory working with a stratified rock mass for different conditions, as well as on the finite element method with the use of nonlinear patterns of change in the stress-strain state of the studied object in the application program package. It has been determined that the composite support section varies in a power law dependence on the ratio of the mine working depth H and the average calculated compressive strength R of the rocks. This makes it possible to predict the stable state of the mine working during the entire life of its operation. The correlation found is between the sectional parameter of the composite support and the H/R ratio, which makes it possible to formulate one of the main scientific conclusions as follows: the load on the composite support of the preparatory working is directly proportional to the power law dependence on the H/R parameter and inversely proportional to the composite support section. This provides a choice of composite support system parameters with reduced material consumption without deterioration of the mine working stability.

Keywords: Chaotic modeling, Mine workings, Composite support, Maximal stresses, Stress-strain state, Rational parameters.

Entropy Decomposition in Mortality Modeling

Apostolos Bozikas

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Abstract

In this work, entropy measures are used to analyze uncertainty in survival outcomes within mortality models. Instead of looking only at overall entropy measures, we focus on how different age-specific components contribute to total survival uncertainty. We develop a component-wise entropy decomposition that separates the contribution of individual model components within a broad class of mortality models. The proposed framework offers a useful tool for understanding and managing uncertainty in longevity risk for practical applications.

Keywords: Entropy, Life expectancy, Mortality Model

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Topological Robustness and Collective Synchronization in the Proteome: A Deterministic Chaos Model based on Feigenbaum-Fibonacci Universal Constants

Simone Caramel

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Abstract

Background: The mechanism by which biological macromolecules maintain structural integrity against entropic noise remains a fundamental challenge in biophysics. We propose a top-down deterministic framework where protein stability is governed by a hierarchy of universal fractal attractors centered on the Golden Ratio ($\phi \approx 1.618$) and the Feigenbaum constant ($\delta \approx 4.669$).

Methods: We introduce the Coherence Coefficient (C_b) and the Collective Phase-Coherence Coefficient (C_{coll}) to quantify the resonance between observed fractal dimensions (D_{obs}) and universal geometric targets. The model was validated against an extensive dataset of **1,000 physiological and pathological protein structures** curated from the PDB (2025/2026), equidistributed across four functional classes.

Results: Our analysis identifies a definitive **'Molecular Habitability Window' (**$0.89 < C_b < 0.95$**)**, corresponding to the 'Edge of Chaos' regime. We observe a discontinuous phase transition: entropic dissolution occurs at $C_b < 0.89$, while pathological rigidity (e.g., prions and amyloid fibrils) manifests as an anomalous shift toward $C_b > 0.985$. The results remain invariant across the 1,000-sample dataset, establishing a **Topological Robustness Factor (**$\phi \cdot \delta \approx 7.55$**)** as a universal buffer against structural perturbations.

Conclusions: These findings suggest that biological health is an emergent property of geometric and phase resonance, actively maintained by a mitochondrial master oscillator. This framework provides a predictive state variable for structural decay and redefines biological stability as **Geometric Homeostasis**, offering new horizons for resonance-based therapeutic interventions.

Keywords: Deterministic Chaos, Topological Stability, Golden Ratio (ϕ), Proteome Synchronization, Mitochondrial Retrograde Signaling, Self-Organized Criticality

DNA-Based One-Time Pad Encryption Method Using Mandelbrot Set and Chaotic Systems

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Abstract: Today, computer-aided encryption techniques have become rather complex due to increasing data security requirements and sophisticated attacking methods. Even though each newly developed encryption algorithm promises high security at the beginning, vulnerabilities that emerge over time and technological advancements may threaten the security of these systems. Particularly, with increased computing power and more developed quantum computing, many encryption methods thought to be secure today may be breakable in the future. Therefore, the fact that each encryption algorithm has theoretically a limited security life and can be broken over time calls for the continuous updating of security measures. These future threats require the development of more innovative and sophisticated encryption approaches. In this study, chaotic systems such as the Lorenz system, logistic map and Hénon map were used and combined with the One-Time Pad (OTP) method to develop a strong DNA-based encryption algorithm. The initial values of the Lorenz system were selected using the logistic map and the initial values of the Logistic map were

determined using the Mandelbrot set and the 1st cipher was created with plaintext by converting these numbers to ASCII codes. Likewise, a new cipher was obtained by creating the 2nd cipher using the Hénon map and converting it into ASCII codes and applying the OTP between the letters. Then, the plain text was encrypted using the One-Time Pad (OTP) key. The encrypted data was first converted to binary codes and then the 0s and 1s in the binary underwent the XOR operation. The binary set obtained following the XOR operation was converted to DNA bases (A, T, C, G). Finally, encryption security is increased by adding complementary DNA sequences. The proposed method provides a powerful solution for data security by utilizing the high information density of DNA and the randomness properties of chaotic systems.

Multifractal Analysis for Fusion Plasma Disruption Prediction

Teddy Craciunescu1, Andrea Murari2,3, Riccardo Rossi4, Michela Gelfusa4 on behalf of JET Contributors* and the EUROfusion Tokamak Exploitation Team**

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§ See the author list of C.F. Maggi et al 2024 Nucl. Fusion 64 112012 https://doi.org/10.1088/1741-4326/ad3e16
£ See the author list of E. Joffrin et al 2024 Nucl. Fusion 64 112019 https://doi.org/10.1088/1741-4326/ad2be4

Abstract: Disruptions are a potential showstopper on the route to developing a tomakak fusion reactor. Since their consequences can be more severe the larger the devices, in the next generation of machines they will have to be carefully managed from the beginning of operation. On the other hand, in new devices, the diagnostic coverage is typically limited and there will be no opportunity to collect many examples for the training of traditional machine learning classifiers. It is therefore important to develop predictors that can ideally operate satisfactorily without training and with minimal diagnostic information. During the last years several approaches based on the identification of dynamical changes in the time series corresponding to routinely available diagnostic signals (locked mode, plasma current) has been developed. Recently, robust evidence of strong variation in the multifractal spectrum of magnetic fluctuations in the discharge phases preceding disruptions has been obtained and used to develop a new disruption prediction method. Close to disruptions the structure of the multifractal spectra becomes characteristic for a cascade process. This specific signature allowed the significant reduction of the false alarm rate. In addition to good statistical

performances, the warning times are sufficient not only for mitigation but also for the prevention of most disruptive events. The method is compatible with a real-time implementation. It has been validated on a large dataset of discharges at JET.

Keywords: Time series, Multifractality, Fusion plasma disruption

Adaptive Fuzzy Sliding Mode Control for Fractional-Order Rossler System Using Grunwald-Letnikov Fractional Integrals

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Abstract

This research presents a novel commensurate fractional-order sliding-mode control (SMC) framework for stabilizing chaotic systems with memory-dependent dynamics. The proposed scheme incorporates discrete Grunwald–Letnikov fractional integrals directly into the sliding-surface design, enabling a memory-aware error dynamics that captures long-term system behavior. The control law integrates three complementary components: linear stabilization gains that provide a Lyapunov-based foundation, nominal dynamics feedforward cancellation to reduce nonlinear coupling, and a lightweight adaptive fuzzy reaching law with a three-level gain strategy that ensures

robustness while mitigating chattering. Stability and performance are verified using Matignon's criterion for fractional-order systems, demonstrating eigenvalue migration from unstable to stable regions, and through real-time tracking of the largest Lyapunov exponent, confirming effective chaos suppression. The approach is validated on fully actuated fractional-order Roessler and Lorenz systems, achieving rapid asymptotic error convergence, bounded control effort, and robust performance

across varying fractional orders. The method provides a computationally efficient, theoretically rigorous, and easily implementable alternative to more complex neural or Takagi–Sugeno fuzzy controllers for fractional-order chaotic system stabilization.

Keywords: fractional-order control, chaos, Grunwald–Letnikov, sliding-mode control, fuzzy adaptive law, Rossler system, Matignon criterion, Lyapunov exponent..

Collective Dynamics and Pattern Relay in Multiplex Time-Delayed Oscillator Networks

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Abstract

Collective dynamics in time-delayed oscillator networks exhibit rich spatiotemporal

patterns whose behavior in multiplex architectures not fully understood. Here we investigate a two-layer nonlocally coupled Mackey–Glass network with instantaneous diffusive coupling. We show that interlayer mean-field interactions can induce transfer of dynamical patterns between layers, leading to the emergence of coherent, incoherent, and chimera states depending on coupling parameters. As the interlayer coupling strength increases, the system undergoes transitions from independent layer dynamics to pattern relay and eventually to

replica synchronization where both layers exhibit identical spatiotemporal behavior. These findings highlight the role of multiplex interactions in shaping delay-induced collective dynamics and provide insight into mechanisms of pattern formation in complex networks.

Keywords: Chaos, Chimera States, Synchronization, Multiplex Networks.

ESG, Homoclinic Orbit and Sunspot Indeterminacy in a Resource Optimal Control Model

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Abstract
In this paper, we analyze how a policy allocating publicly provided renewable energy capacity to firms that satisfy an Environmental, Social, and Governance (ESG) threshold reshapes the global dynamics of a continuous-time optimal control model with externalities. We extend the existing literature by introducing a policy induced wedge that may generate global indeterminacy and sunspot equilibria in a tubular neighborhood of the parameter region in which a homoclinic orbit emerges. In this setting, non-fundamental belief shocks may act as sunspots, selecting among multiple admissible equilibrium trajectories. Because ESG classifications are known to vary substantially across providers, we model the ESG threshold as an operational rule robust to rating disagreement, consistent with the evidence in Berg et al. [2022].
Keywords: Optimal Control Model, Environmental, Social, and Governance (ESG) threshold, Homoclinic Orbit, Sunspot Equilibria.

When Supply Chains Meet Chaos: Nonlinear Dynamics of Commercial Traffic in London

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Abstract: Commercial mobility systems in large metropolitan areas can be viewed as high dimensional dynamical systems in which freight vehicles, service fleets, and other transport modes interact through nonlinear feedback, network constraints, and behavioural adaptation. To determine whether such systems exhibit deterministic chaotic structure or high order stochastic complexity, this study analyses one minute commercial mobility data from TomTom, including car, heavy vehicle, van, and cycle trajectories along major logistics corridors in London. The methodological framework is grounded in nonlinear time series analysis, attractor reconstruction, and spectral–entropy characterisation.
The underlying dynamics are reconstructed using Takens' embedding theorem, with embedding dimension and delay selected through false nearest neighbour minimisation and mutual information analysis to ensure a diffeomorphic reconstruction of the system's invariant manifold. On the reconstructed attractor, we compute dynamical invariants such as the maximal Lyapunov exponent, the correlation dimension, and a full suite of recurrence quantification measures, enabling a detailed assessment of local divergence rates, attractor geometry, and temporal persistence. To distinguish deterministic chaos from coloured noise processes, we employ phase randomised and amplitude adjusted surrogate tests, evaluating the statistical significance of the

estimated invariants against null distributions implied by linear stochastic dynamics.
Spectral properties are examined through continuous wavelet transforms and scale dependent entropy measures, allowing decomposition of system energy across temporal frequencies and identification of nonlinear coupling between short run stop and go oscillations and slower congestion driven modes. Heavy vehicle flows during peak delivery windows exhibit positive Lyapunov exponents, low to moderate attractor dimensionality, and non Gaussian recurrence structures, consistent with low dimensional chaotic dynamics. These instabilities propagate through the network, amplifying uncertainty in routing, delivery scheduling, and supply chain reliability. The framework provides a mathematically rigorous basis for diagnosing nonlinear instability in commercial mobility systems and for quantifying operational risk in urban freight logistics

Control Synthesis Problems for Nonlinear Dynamical Systems under Uncertainty

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Abstract
The control problems for set-valued trajectories of a nonlinear dynamic system described by differential equations with nonlinearity and uncertainty are studied. It is assumed that only the bounding sets for uncertain variables are known and any additional statistical information is not available. Approaches are described for solving the optimal control problem for such systems, including the problem of the fastest

transfer of the system state inside a given terminal set. The research develops previous theoretical schemes and approaches [1,2]. Numerical simulations related to the proposed techniques and based on new state estimation ideas and on new algorithms are included to illustrate the main results. The study is partially supported by the Research and Education Center of IMM UB of RAS in the framework of the Ural Mathematical Center.
Keywords: Nonlinear dynamics, Uncertainty, Ellipsoidal calculus, State estimation, Differential inclusion, Trajectory tube, Control synthesis

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Global Bifurcations, Chaos and Multi-Stability in Polynomial Dynamical Systems

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Abstract
Studying global bifurcations of limit cycle, we investigate multi-stability and chaos in polynomial dynamical systems. First, using our new bifurcation and geometric methods, we solve Hilbert's Sixteenth Problem on the maximum number of limit cycles and their distribution for the 2D Liénard and Euler-

Lagrange-Liénard polynomial, Holling quartic, Leslie-Gower quintic-sextic, and also Kukles cubic-linear and Kohlmeier-Ebenhöh cubic-quadratic dynamical systems. Then, applying a similar approach, we study 3D polynomial systems. In particular, we complete the chaos transition scenario for the classical Lorenz system connecting globally homoclinic, period-doubling, period-halving and Shilnikov type bifurcations of its limit cycles which is related to Smale's Fourteenth Problem. We also carry out a global bifurcation analysis of the 3D Topp model for the dynamics of diabetes.

Keywords: Polynomial dynamical system, Bifurcation, Limit cycle, Chaos, Multi-stability.

Discrete Lorenz attractors of various types in three-dimensional maps with axial symmetry

Aleksandr Gonchenko

Anomalous Brownian dynamics of a point in a field of several central forces localized in a small region

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Abstract

The report presents the results of modeling anomalous Brownian dynamics of a point (ABDP) in a field of several central forces. It is shown that, in general, the BDP attractor has

a fractal nature and is concentrated in the contour $A_1A_2A_{3...}A_N$, where A_1; A_2; A_3; …; A_N are the points of application of central forces. However, when $A_1A_2A_{3...}A_N$ are localized in a very small region *d*, the attractor exhibits anomalous behavior, forming a family of concentric orbits, the largest of which has a diameter $D >> d$. In most cases, concentric orbits are separated from each other by an amount $\Delta R \approx$ cost. The number of such orbits can range from one to several dozen and depends on the parameters of the central forces, the modulus of their field, the dimensions *d*, and the transparency of the central force barriers. The report provides quantitative data of the sizes of the orbits, their number, and the width of the orbit rings from the control parameters of the model. Such anomalous Brownian dynamics of a point allows modeling the kinetics of the formation of discrete systems: both large planetary systems and very small systems, such as the planetary model of an atom.
As can be seen from Fig. 1, the obtained discrete orbits have characteristic features of fractal structures.

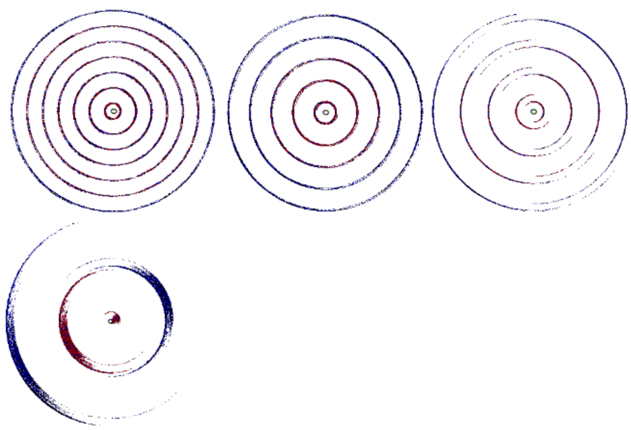

Fig. 1. Examples of the synthesis of discrete concentric orbits of ABDP in the field of three central forces localized in the region d<<D. Number of orbits K = 7, 5, 5, 2.

Keywords: Multifractals, Discrete concentric orbits, anomalous Brownian dynamics of a point

Quantitative models of phase transitions "Competition-monopoly"

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Abstract
The report shows that competitive contests in economics, politics, biology, sports, etc. can be quantitatively investigated using a percolation model. In this case, the transition of a system from a state of perfect competition to a state of monopoly is an example of a phase transition that can be well modeled quantitatively within the framework of the percolation model, one of the well-studied methods of quantitative research of phase transitions. Based on the Percol and Percol-Statistic software products we have developed, we propose a methodology for quantitative modeling of phase transition kinetics over a wide range of control parameter variations. The report shows that generalization of the modeling results revealed four areas of kinetics of connecting cluster formation, listed in table below.

P	P_1	P_2	P_3	P_4
	$P_1 << P^*$	$P_1 < P_2 < P_*$	$P_3 \approx P_*$	$P_4 > P_*$
m	1	1.5	2	2.5
	Competition	Transition area	Monopoly	
R^2_{log}	> 0.9	0.7…0.9	0.5…0.7	< 0.5
R^2_{hip}	< 0.5	0.5…0.7	0.7…0.9	> 0.9

where P_* is the percolation threshold.
For all four areas, the formation of cluster rating diagrams is described by differential equation (1)

$$\frac{dQ}{dt} = \frac{A}{B * t^m} \qquad (1)$$

Thus, for m = 1, we obtain a semi-logarithmic model of the rating diagram:

$$Q(t) = Q_1 - C * \ln(t) \qquad (2)$$

And for m > 1 – a hyperbolic model of the type:

$$Q(t) = \frac{Q_1}{B * t^{m-1}} \qquad (3)$$

The report provides experimental confirmation of dependencies (2) and (3).

Keywords: Percolation models, Competition and Monopoly, Phase transition, Rating chart.

On Analysis of Music Using Dynamical System Tools

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Abstract

The connection between physics and music has been of interest since Helmholtz [1] since both involve evolution in time. Dynamical System tools such as time series analysis, attractor reconstruction, fractal analysis is being widely used to analyze and compare musical works composed in the last two centuries. [2, 3] Wagner's "Tristan and Isolde" is a very important and influential example of the transition to a more modern approach in opera, harmony and chromaticism [4]. A detailed analysis involving dynamical system tools, of material such as the significance of envelope analysis, with emphasis on Timbre Definition, Sound Design, Musical Rhythm and Meter Perception leading to Temporal Precision, Duration and Fluctuations in the amplitude envelope will be primary clues for perceiving the musical content of this work and will by studied in this presentation. Dynamical system tools such as R/S and Detrended Fluctuation Analysis, and where needed Diffusion Entropy Analysis. Lyapunov Exponents will be employed, results will be presented and discussed. Preliminary results

strongly support complexity but does not indicate chaos although it does not rule out edge of chaos behavior since signs such as DFA above 0.6, high diffusion entropy and marginally positive maximal Lyapunov exponents sometimes occur.

Keywords: Complexity, Chaotic structures in music, time series analysis, attractor reconstrıuction, fractal measures, 1/f noise, Hurst, DFA, DEA.

Numerical Approximation of Stochastic Elliptic PDES with Random Inputs

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Abstract

This work aims to implement efficient solution algorithms for linear parametric elliptic partial differential equations (PDEs) problems with random coefficients. Our typical method is the stochastic Galerkin finite element method for the numerical solution on a finite-dimensional parameter space. More precisely, stochastic Galerkin finite element approximation of PDEs with random fields leads to linear systems of equations with coefficient matrices that have a characteristic Kronecker product structure. By reformulating the systems as multi-term linear matrix equations, we develop an efficient solution algorithm that is based on rational Krylov subspace approximation. We present the same algorithm with the arcsine law applied to stochastic elliptic PDEs, and an adaptive mesh refinement process for parametric elliptic PDEs with random coefficients to give good results.

Keywords: Stochastic Elliptic Partial Differential Equation, Stochastic Galerkin Finite Element Method, Adaptive Algorithms Algorithms,Karhunen-Loeve expansion, Numerical approximation.

Two-Loop Renormalization of the Incompressible Toner–Tu Model

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Abstract
We investigate fluctuation-driven dynamics in incompressible active matter by extending the field-theoretic renormalization group analysis of the Toner-Tu model beyond leading order. Active matter systems are intrinsically non-equilibrium, featuring strong nonlinearities and persistent stochastic forcing that can amplify fluctuations across scales and generate irregular, disorder-dominated dynamics.
Starting from a stochastic hydrodynamic description and enforcing incompressibility, we construct a non-equilibrium field theory and analyze it perturbatively. While the one-loop structure reproduces known scaling behavior and fixed points, our focus is on the qualitative and quantitative impact of two-loop corrections on the renormalization group flow.
We examine how these corrections modify beta functions, shift fixed points coordinates, and alter the stability of dynamical regimes. The resulting renormalization group flow refines the phase diagram and contributes to a comprehensive understanding of emergent collective dynamics in active matter systems.
Keywords: active matter, field-theoretic renormalization group, turbulent advection

Bifurcations of Maximal Attractors in Non-Ideal Pendulum Dynamical Systems In-duced by Time Delay

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Abstract

This study examines the oscillations of a spherical pendulum excited by an electric motor of limited power. Such a system is classified as a non-ideal dynamic system in the Sommerfeld-Kononenko sense. A mathematical model is constructed that accounts for the time delay in the interaction between the excitation source and the pendulum's oscillations, and vice versa. The limit sets and their bifurcations are investigated under varying delay values.

It is established that the limit sets of the "spherical pendulum – electric motor" system, excluding sets of zero measure, consist exclusively of maximal attrac-tors (Milnor attractors). Furthermore, the existence of both regular and chaotic maximal attractors is demonstrated. It is shown that time delays can play a de-cisive role in the emergence and disappearance of deterministic chaos within the system. In particular, as delay values change, a maximal regular attractor can transform into a maximal chaotic one and vice versa.

The maximal attractors of the "spherical pendulum – electric motor" system do not satisfy the "classical" definition of an attractor. Nevertheless, it is shown that transitions to deterministic chaos in such a system follow typical scenarios inherent to conventional attractors. Specifically, the role of time delays in facili-tating transitions to chaos via the Feigenbaum and Manneville-Pomeau scenar-ios is investigated. Additionally, a transition from a maximal chaotic attractor of one type to a maximal chaotic attractor of another type is described accord-ing to the generalized intermittency scenario.

Keywords: delay, maximal regular & chaotic attractors, limited excitation, scenarios of transition to chaos

Adiabatic Theory of Strongly Chirped Dissipative Solitons

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Abstract
We present the adiabatic theory for strongly chirped dissipative solitons in the cubic–quintic complex Ginzburg–Landau equation, with an emphasis on physically transparent energy (mass)-scalability criteria for the dissipative soliton (DS) laser oscillators and metaphoric modeling of Bose-Einstein condensates. The proposed adiabatic approximation and regularization techniques yield closed-form solutions for the peak power, energy, and stationary-phase spectra of DSs. That provides a compact dimensionless mapping of the soliton existence domains in both the normal- (NGD) and anomalous group-delay dispersion (AGD) regimes. A central outcome is that the DS resonance (DSR), which means a chirp-driven temporal stretching at bounded peak power, arises naturally in both regimes. The DSR is associated with the DS energy divergence in the master diagram of the DS parameter space. We show that DSR persists in NGD for a finite quintic self-phase modulation. In AGD, DSR occurs within the adiabatic existence window, beginning from a finite level of quintic self-phase modulation. The analytically derived spectral profiles (the truncated Rayleigh–Jeans–like in NGD and algebraically tailed

in AGD) enable a thermodynamic characterization of DS and provide quantitative indicators of resonance, breakup onset, and transitions to multi-soliton states.

Norges Forskningsråd supported this work (#303347 (UNLOCK), #326503 (MIR)). We acknowledge using the IDUN NTNU scientific cluster.
Keywords: Dissipative Soliton, Cubic–Quintic Complex Ginzburg–Landau Equation, Adiabatic Approximation, Dissipative-Soliton Resonance, Chirped-Pulse Oscillators, Thermodynamics of Non-Equilibrium Dissipative Systems

A Fractional-Order Dynamics of Societal Sustainability: A Study on Memory Effects and Predictability in the HANDY Model

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Abstract
This study proposes a fractional-order extension of the Human and Nature Dynamics (HANDY) model, originally developed by Motesharrei et al. [1], to incorporate power-law memory effects into the simulation of societal sustainability and resource use. While the original model employs four integer-order differential equations to represent the interaction between commoners, elites, nature, and wealth, the proposed fractional framework accounts for historical consumption habits and delayed ecological responses. To overcome the analytical bottlenecks posed by the system's inherent discontinuities—specifically in consumption thresholds and death rates—we utilize the numerical smoothing methodology established in previous studies by Hacınlıyan and Kandıran [2]. By

approximating these discontinuities with differentiable sigmoid functions, such as the hyperbolic tangent (tanh), we enable the reliable calculation of the Jacobian matrix, which is essential for determining dynamical invariants. The research focuses on a quantitative comparative analysis between integer and fractional versions of the system, employing stability, maximal Lyapunov exponents, and Kaplan-Yorke dimensions to classify its chaotic nature. The findings demonstrate that the fractional derivative order (α) serves as a critical control parameter that can either expand or contract the system's predictability horizons, offering a more nuanced understanding of the long-term stability and potential for irreversible collapse in stratified complex societies.

Keywords: Chaotic modelling, Fractional-order systems, Lyapunov exponents, Chaotic simulation, Power-law memory.

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Modelling and Computer Simulation of the Turbulent Two-Phase Jets of Nano fluids

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Abstract

The present paper is devoted to the mathematical modelling and computer simulation of the mixing and heat transfer processes in the two-fluid turbulent heterogeneous jet flow of

Nano fluids. Many natural and technical processes deal with the turbulent jets of mutually immiscible liquids, which represent an important class of the modern multiphase system dynamics including the ones for the features of Nano fluids. Differential equations for the axially symmetrical two-dimensional stationary flow and the integral correlations in a cylindrical coordinate system were considered for the jet of fluid from a nozzle into a space filled with another fluid that is not miscible with the first one. Parameters of the turbulent mixing during the spreading of such jets are modeled and analyzed. The method was proved successfully during the half of the century in many different physical tasks including experimental studies with using the invented two-phase micro-sensor. The results obtained for the flow of a few Nano fluids may be of interest for the research and industrial tasks, where the calculation of multiphase turbulent mixing and heat transfer are important.

Pears and Peanuts versus Escher Zones: Nonlinear Shape Dynamics in Low-Dimensional Shape Space

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Abstract

Complex 3D shapes often admit simple informal labels (“pear-like”, “peanut-like”), but their evolution under deformation, noise or projection can pass through ambiguous configurations where classification becomes unstable. This contribution introduces a dynamical viewpoint on such “pears and peanuts”, based on low-dimensional morphological indices previously developed for the PnP endpoint morphospace. These indices map high-resolution 2D silhouettes (or segmented images) of 3D bodies to a small “shape state vector” with clear geometric

meaning (e.g. necking strength, mass skewness, asymmetry), via a nonlinear transformation.
Time-dependent shape changes are considered — synthetic morphs between pear-like and peanut-like profiles, together with illustrative examples inspired by real objects — and the induced trajectories in the resulting low-dimensional shape space are analysed. Within this space, “Escher zones” are identified: regions where nearby states correspond to qualitatively different informal labels, and where tiny perturbations in contour or viewpoint lead to large changes in perceived morphology. These zones act as natural markers of high sensitivity and classification ambiguity, and they suggest shape-based observables for nonlinear dynamics and chaos studies in physical systems (e.g. evolving catalyst grains or soft-matter droplets). A more detailed static construction of the PnP indices and their endpoint morphospace will be presented elsewhere; here the focus is on their time evolution and the emergence of Escher-like ambiguity regions in shape space.
Keywords: Nonlinear shape dynamics; low-dimensional morphospace; morphological indices; silhouette-based shape descriptors; classification instability; sensitivity to perturbations; Escher zones; shape trajectories; chaos/complexity observables.

Bifurcation and stability in transportation dynamics

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Abstract: Many processes in transportation are governed by issues of capacities and flows. Two kinds of capacities must be distinguished in transportation: i) the storage capacity, a static property dependent of the infrastructure, and ii) the maximum flow at any given point, which is a dynamic property resulting from the qualities of the infrastructure and of the vehicles using the infrastructure. Typical examples of critical dynamical processes at the network level are given by network gridlock (Mahmassani et al 2013), network level congestion (Li et al 2015, Sundresh 2023), and complex behavior in dynamic traffic assignment (Daganzo 2011, Khoshyaran and Lebacque 2023). At the local level of intersections, the so-called capacity drop phenomenon constitutes a major dynamic process. Capacity drop results from a loss of through-flow capacity when an infrastructure recovers from congestion and it strongly impacts traffic management (Leclercq et al 2011). This loss of capacity can be traced back to the boundedness of vehicular acceleration (Lebacque 2002), as has been analyzed in several studies (Monamy et al 2012, Khoshyaran and Lebacque 2015, Jin et al 2015). From a dynamic point of view, gridlock and capacity drop are quite similar and can be modeled by similar tools. The macroscopic description of very large networks by macro-cells (Khoshyaran and Lebacque 2025, Mousavizadeh and Keyvan-Ekbatani 2026) and the description of intersections by buffers (Monamy et al 2012, Laurent-Brouty et al 2020) are endowed with similar dynamical properties.

The thrust of this contribution is that traffic dynamics induced by multi-reservoir type storage facilities combined with strongly non-linear flow dynamics are liable to exhibit discontinuities, bifurcations and complex behavior (Daganzo et al 2011, Cianfanelli et al 2022), which we aim to analyze. Further we will address issues of structural stability, which are very important when considering such complex systems.

Keywords: Dynamic traffic assignment, infinite dimensional systems, capacity drop, network grid-lock, complex system, fixed point, equilibrium, structural stability.

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A.L.I.G.N.E.D. Framework: A Supervised GenAI Approach for Aligning H5P Learning Activities with Public-Sector Digital Skills Gaps

Nikos Kounoupas, Yiannis Dimotikalis and Christos H. Skiadas

A.L.I.G.N.E.D. Framework: A Supervised GenAI Approach for Aligning H5P Learning Activities with Public-Sector Digital Skills Gaps

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Abstract

This paper presents the A.L.I.G.N.E.D. Framework, an explainable methodological framework for aligning public-sector employees with personalized H5P learning activities on the basis of documented digital-skills gaps. The study was grounded in the DESI 2023 Human Capital dimension and followed a mixed-methods design. Quantitative data was collected from 140 employees through a 57-item DigComp 2.2 self-assessment instrument and analyzed in SPSS using Cronbach's alpha, chi-square tests, Ward-linkage clustering, frequency analysis, factor analysis, Pearson correlations, and one-way ANOVA. Qualitative data from 13 interviews were analyzed in ATLAS.ti to identify contextual training needs and workplace practices. In parallel, 85 H5P activities were developed and deployed on a WordPress platform.

The core contribution lies in the alignment pipeline. Questionnaire items were mapped to DigComp axes, subskills, and Knowledge-Skills-Attitudes (KSA) dimensions, while activity learning objectives were encoded in the same competency space. To resolve incompatibilities between questionnaire-level subskills and more granular activity objectives, the framework introduced a normalized common reference layer (Subskill_Group), enabling reliable joins, KSA-sensitive scoring, and explainable recommendations. Activity profiles were compressed to avoid score inflation, learner responses were transformed into KSA-specific gap profiles, and an interpretable ActivityScore was calculated through weighted alignment between learner gaps and activity coverage, followed by ranking, deduplication, diversity constraints, and evidence-based enrichment.

A distinctive feature of the framework is its explicit domain grounding in Local Government Authorities (LGAs): the learning objectives were not generic but framed around realistic public-administration tasks such as document verification, citizen service, official communication, and lawful publication practices. GenAI supported content generation and procedural execution through a structured, researcher-defined protocol. This human-in-the-loop approach ensured that the researcher maintained continuous oversight, inspecting all intermediate outputs, verifying the logic of data joins and scoring, and retaining final authority over the validation and synthesis of recommendations. The framework is therefore directly relevant to human resource development in public administration, enabling scalable, targeted, and explainable digital-skills training for LGA staff.

Keywords

DigComp 2.2; GenAI; H5P; A.L.I.G.N.E.D.; Public Administration; Digital Skills

Investigation of the instability and dispersion of waves in plasma and gas-dust space media

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Abstract

Instability is a distinctive feature of the phenomenon of self-organization in complex systems. In his study of plasma, A.A. Vlasov neglected collisions and wrote down a self-consistent system of equations [1] for the distribution function and Maxwell's equations. Essentially, the Vlasov equation itself is a consequence of the fact that plasma is *quasi-neutrally* one. After linearization and in the absence of collisions (due to the rarefied plasma), the existence of both transverse and longitudinal electromagnetic waves was demonstrated, for which the *dispersion dependence* of frequency ω on the wave vector $\vec{k}$ has the form [1]:

$$\omega = \omega_L \sqrt{1 + 3\left(R_D\left|\vec{k}\right|\right)^2}\,, \tag{1}$$

where $R_D = \left(k_B T / 4\pi n \bar{e}^2\right)^{1/2}$ is the Debye–Hückel radius, which determines the screening radius of the Coulomb interaction in the plasma, ω_L is the Langmuir frequency of the electron plasma, T is the temperature of the electron plasma, k_B is the Boltzmann constant, n is the electron concentration in the plasma, $m_{\bar{e}}$ is the electron mass, and $\bar{e}$ is the electron charge.

The problem of gravitational condensation of an infinitely spread cosmic medium is closely related to the problem of *gravitational instability*. The linearized theory of instability, developed by J. Jeans [2], showed that in a gravitating medium, the *dispersion* equation is valid:

$$\omega = \left|\vec{k}\right| c_s \sqrt{1 - \left(k_c / \left|\vec{k}\right|\right)^2}\,, \tag{2}$$

where $k_c = 2\pi / \lambda_c = \sqrt{4\pi\gamma\rho} / c_s$ is the *critical* Jeans wave number, and c_s is a speed of the sound wave, ρ is a mass density.

A look at the two dispersion equations (1) and (2) shows that in plasma, longitudinal oscillations are stable oscillations, while in gravitationally bound stellar gas, sound oscillations, which can be called *longitudinal* gravitational oscillations, are *stable* only

under the condition $k > k_c$. In gravitationally bound stellar gas, *transverse* gravitational oscillations also exist, which are also stable under the condition $k > k_c$.

A statistical theory of the formation of a cosmogonical body was proposed in previous studies [3]–[5]. Within the framework of this theory, the propagation of plane monochromatic gravitational waves in the gravitational field of a condensing cosmogonic body is studied. It is shown that in this case, the gravitational instability criterion of form (2) also holds, i.e. the *dispersion* law is true for the *longitudinal* monochromatic gravitational waves in the gravitational field of a condensing spheroidal body:

$$\omega = |\vec{k}|\upsilon_{ph} = \frac{|\vec{k}|c_{\mathrm{g}}}{\sqrt{1+\left(4\pi\gamma\rho/|\vec{k}|^2\right)\left(r\alpha(t)/g^{(\mathrm{I})}\right)}}, \qquad (3)$$

where υ_{ph} is a phase speed, α is a parameter of gravitational condensation, $g^{(\mathrm{I})}$ is a magnitude of strength of the irrotational gravitational field. This gravitational instability criterion also manifests itself significantly for long waves. However, for some sufficiently large waves λ, the phase velocity υ_{ph} of a longitudinal gravitational wave disappears completely $(\upsilon_{ph} \to 0)$, i.e. the gravitational wave collapses, and its frequency $\omega \to 0$.

Keywords: plasma and gas-dust space media, Vlasov dispersion law, gravitational instability, Jeans criterion, ethereal medium (dark matter), slow-flowing gravitational condensation, equation of a moving "liquid" particle in "quasi-solid" approximation, equations of the gravitational/gravimagnetic fields, dispersion law for gravitation waves

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Chaos Theory and Meaning In Natural Languages

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Abstract
Modern linguistics is in thrall to the belief that the relationship between the sound patterns of words and the meaning conveyed by those words is 'arbitrary'. In this paradigm, there is said to be no intrinsic relation between the form of a word and its meaning. So, for example, the sound pattern / *c a t* / bears no relation to any salient facts about domestic cats or any of their relatives in the *Felidae* family. The word 'cat' according to this interpretation is simply a label that has to be learned. Although this perspective on sound-meaning relations has held sway in linguistics throughout the long life of the scientific study of languages, it is fundamentally incorrect. In this paper, I explain how I was able to hack into the inner dimension of the English language—the input function, where symbolic sound and meaning are matched in a black box in the unconscious—to reveal a highly ordered architecture of Meaning at the core of the language, an architecture that prefigures and underpins its lexicon, grammar and syntax. The system of meaning revealed through this methodological approach demonstrates that the relationship of sound to meaning in languages is anything but unstructured and chaotic. The implications of this discovery as it relates to Meaning cannot be overstated. In this new paradigm, languages are seen to be coherent, self-regulating systems that owe nothing to outside influences, and which display a self-similar geometry reminiscent of other seemingly chaotic systems and structures. This new insight into the inner life of languages opens up a radically different perspective on

the true nature of natural languages and has wide-ranging implications not only for how languages emerge, and how they grow, but extends to the role languages play in cognition generally. Significantly, the discovery of this behind-the-scenes, Meaning-based architecture also proves to be the key to solving the longstanding riddle of how consciousness arises in modern humans. **Keywords:** Chaotic modeling, Sound-meaning relations in languages, Architecture of Meaning, Meaning-based modeling, Self-Organization, Self-similar geometry, Consciousness.

Lyapunov Exponents as a Pathway to Characterize Biological Parameters through Locomotion

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Abstract
We present a series of studies on the locomotion dynamics of Caenorhabditis elegans. The experimental time series was obtained using Dynamic Optical Diffraction (DOD). This approach enables high-resolution, out-of-plane tracking of microscopic motion without the need for traditional imaging. We report the Largest Lyapunov Exponents (LLEs) for control organisms and compare them with those of aged specimens and nematodes exposed to microgravity. Additionally, we provide the full Lyapunov spectrum for the control group, which reveals that the underlying locomotion dynamics exhibit hyperchaotic behavior.
Keywords: hyperchaos, chaos, dynamic diffraction, C. elegans

Application of the First Exit Time Model–IM to Survival (Raw) Data for the U.S. Population

George Matalliotakis[1], Christos Skiadas[2], Stamatia Margariti[3]

Abstract

In this article, the stochastic First Exit Time Model (IM) is applied to survival data for the male and female populations of the United States for the year 2004. The data were obtained from Human Mortality Database. The First Exit Time Model–IM is a multiparametric stochastic model whose main advantage is that it successfully describes infant mortality with high accuracy. As shown by the analysis of the survival data and their fitting to the stochastic First Exit Time -IM model, the model demonstrates a good fit for both males and females in the year 2004, yielding useful findings related to actuarial science and demography. Furthermore, the First Exit Time – IM has several similarities to the Quadratic Model and provides better results in the analysis of infant mortality data compared to other mortality models.

Application of the Three-Parameter Weibull Model to Greek Population Survival Data: Insights into Age- and Gender-Specific Mortality Patterns

George Matalliotakis[1], Christos Skiadas[2], Stamatia Margariti[3]

Abstract

This article studies the application of the Weibull deterministic model to the survival data of the Greek population, using primary data. The database from which the data were obtained, was the Human Mortality Database. To apply the model we used the non-linear regression method, which showed that the model provides a good fit to the data, while deviations are observed during adolescence and middle adulthood for both males and females.The analysis of the data leads to significant demographic conclusions, such as differences in mortality based on gender and lifestyle.

Stochastic Modeling of Survival in the Australian Population: Comparative Analysis of the First Exit Time and Deterministic Weibull Model

George Matalliotakis[1], Christos Skiadas[2], Stamatia Margariti[3]

Abstract

In this article, a comparison between the Weibull Model and the stochastic First Exit Time Model is conducted in fitting survival data for Australian males and females for the years 1985, 1995, 2002 and 2003. The survival data (raw data) were obtained from the Human Mortality Database. From the fitting of the data and the calculation of the appropriate statistical indicators, it is concluded that the stochastic First Exit Time Model provides a better fit than the Weibull Model across the entire range of age categories for both the male and female populations. Specifically, the stochastic First Exit Time Model demonstrates a better fit at younger ages (early adulthood) and at very old ages (advanced ages) compared to the Weibull Model. The analysis of the data indicates that the First Exit Time constitutes a modern and reliable tool for the analysis of demographic data, as it has the ability to describe the multi-parameter nature of human survival.

A Nonlinear Stochastic Population Model with Allee Effect and Behavioral Fear Effect

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Abstract

Mathematical models of predator–prey systems play a central role in ecology and evolutionary biology. In recent years, numerous studies have shown that the size of a prey population changes not only due to deaths caused by predation but also as a result of the fear effect arising from the presence of predators in the system. Accordingly, in various mathematical population models, the fear effect is generally represented in the form of a function that acts multiplicatively on the growth rate. However, modeling the fear effect solely as a reduced multiplicative factor added to the growth rate leads to an inadequate description of the nonlinear feedback mechanisms that emerge in the system.

In this study, we propose a new nonlinear single-species model in which the fear effect determines population dynamics simultaneously through multiple mechanisms. In our model, we consider a population evolving under the Allee effect and formulate the fear parameter so that it acts both as a multiplicative feedback affecting the growth process and as a factor influencing a Holling Type III–like saturation term that describes predation pressure. In this way, we treat the fear effect not only as a biological stress factor but also as a fundamental component that restructures population dynamics through behavioral feedback.

We render our deterministic model stochastic by formulating it in terms of a Langevin equation that incorporates both additive and multiplicative noise effects with zero-mean white noise terms, and we analytically obtain the steady-state solution of the system within the framework of the corresponding Fokker–Planck formalism. We extend our model

to generate two different dynamical scenarios depending on the sign of the interaction term and show that these lead to different stability structures within the same mathematical framework. In addition, we present Mean First Passage Time (MFPT) analyses that reveal the effects of fear and fluctuations on the time required for the population to go extinct or to reach critical thresholds. As a result, we demonstrate that the fear effect should be regarded not merely as a biological stress source but as a fundamental component that reshapes population structure through behavioral feedback, and we show that fear intensity and stochastic fluctuations lead to pronounced regime changes in the stationary population structure.
Keywords: Population Models, Stochastic Population Dynamics, Fear Effect, Langevin Equation, Fokker-Planck Equation, White Noise.

Learning Turbulent Transport in Tokamaks from the Chaos of Test-Particle Simulations

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Abstract: Fusion devices, particularly tokamaks, exhibit significant radial transport driven by chaotic particle motion in turbulent drift-type fields. Understanding how turbulence statistics (Eulerian properties) determine transport levels (Lagrangian properties) remains a key challenge for predicting turbulent transport. In many regimes the transport is anomalous and difficult to model with conventional approaches. In this work we present a proof of concept for applying supervised learning methods - regression models and neural networks - to capture the nonlinear relation between turbulence statistics and transport. Training data are generated from test-particle simulations performed with the newly developed T3ST code. Our results show that even with

relatively small datasets, physically informed regression models can provide accurate and computationally efficient predictions of turbulent transport.
Keywords: Tokamak, Turbulence, Transport, Simulation, Regressions.

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them. This work was also supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS - UEFISCDI, project number PN-IV-P2-2.1-TE-2023-1102, within PNCDI IV

Creep strain behaviour in reinforced concrete silos for variable temperatures

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Abstract

This work aims to study the most used silo´s geometry in Guerrero, Mexico. A concentric conical hopper concrete silo that stores cement under high temperatures, to compare be-tween two loading cases. The first case develops creep strain due to the static loading condi-tion during the first 210 days of the primary creep stage which is analyzed by Time Harden-ing Law. After this time, in the secondary creep stage the stationary creep is evaluated for 20 years by Norton´s Power Law, this second case experiments a seismic load after 210 days primary creep started. Time-history analysis, with a synthetic acceleration signal built

based on the provided data by Prodisis CFE software, is carried out to evaluate the seismic load. After applying a seismic dynamic loads the secondary creep stage is evaluated for a period of 20 years. Equivalent creep strain is shown to examine the response in the primary creep stage, velocity an d displacement for seismic analysis and the principal axes strains compari-sons for secondary creep stage. In this way, through the comparison between the behaviour in seismic and non-seismic presence, this paper intends to deepen on the study of creep dy-namic behaviour in concrete silos in one of the main seismic zones in Mexico.

Anomalous scaling and anisotropy persistence in kinematic magnetohydrodynamic turbulence

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Abstract

The scaling inertial-range behavior of the single-time two-point correlation functions of the weak magnetic field, passively advected by the turbulent velocity field driven by the stochastic Navier-Stokes equation, is investigated in the framework of the field-theoretic renormalization group approach in the second order of the corresponding perturbative expansion (in the two-loop approximation in the language of quantum field theory). The explicit two-loop expressions for the corresponding scaling exponents are found and compared to those obtained in the Kazantsev-Kraichnan model of the kinematic magnetohydrodynamics with the simple Gaussian statistics of the turbulent velocity field. It is shown that, in general, the presence of higher correlations of the velocity field in the turbulent kinematic magnetohydrodynamics leads to more pronounced anomalous scaling behavior of the magnetic correlations deep inside the inertial interval. Moreover, the analysis of the asymptotic behavior of dimensionless ratios of

the single-time two-point correlation functions of the magnetic field shows that even the persistence of anisotropy deep inside the inertial range is more pronounced in the genuine kinematic magnetohydrodynamics with the Navier-Stokes turbulent velocity field than in the Kazantsev-Kraichnan model of the kinematic magnetohydrodynamics with the complete absence of higher correlations of the turbulent velocity field.

Keywords: Turbulence, Stochastic dynamics, Navier-Stokes, Magnetohydrodynamics, Anisotropy, Anomalous scaling

Comparing the Chaotic Locomotion of C. elegans in Simulated Microgravity vs. Control Conditions Using the Rosenstein Algorithm

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Abstract

This study captures the locomotion of Caenorhabditis elegans (C. elegans) using dynamic diffraction in a time series. The largest Lyapunov exponent (LLE) of the time series varies differently with age in microgravity versus Earth's gravitational field. Previous work on C. elegans has indicated that their locomotion in control conditions is chaotic and follows a curve that matches Moore's equation. We identify differences in nematode locomotion after growing the samples in a random-position machine (RPM), which simulates microgravity conditions. We have estimated the Largest Lyapunov Exponent (LLE) for ages 3 days through 9 days using the Rosenstein algorithm. Preliminary results from the microgravity study show a deviation in the curve observed under control conditions and in higher LLE results, varying from 0.03 ± 0.1 sec-1 to 0.49 ± 0.1 sec-1.

A New Non-Autonomous Chaotic Generator: Circuit Realization and Analysis of the Main Properties

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Abstract
In this paper, circuit realization and computer modelling analysis of a new non-autonomous chaotic generator are shown. A new non-autonomous chaotic generator consists from one operational amplifier, two diodes, one capacitor, one inductor, four resistors, and one voltage source. All component nominals that realized this non-autonomous chaotic generator are presented. NI MultiSim software environment was used for computer modelling of the main information properties such as chaotic attractor, time series, and spectral characteristics for two X and Y signals. This generator can be used as a main block for masking of information carrier in modern telecommunication systems.
Keywords: Non-autonomous, Chaotic, Generator, MultiSim

Stability and chaos in a heterogeneous duopoly game with generalized profits and R&D efforts

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Abstract
In this paper, we examine a duopoly model with homogeneous products in which two heterogeneous firms make decisions

related to research and development (R&D) efforts under generalized profit objectives. The model assumes linear production costs and quadratic R&D expenditures, while firms differ in their behavioral rules. One player behaves as bounded rational player, whereas the other as a naïve player. We investigate the existence and local stability of the equilibrium points of the system. The results show that the adjustment speed of the bounded rational player plays a crucial role in the dynamic behavior of the model. Numerical simulations, including bifurcation diagrams, Lyapunov exponents, and phase portraits, reveal that sufficiently high adjustment speeds may destabilize the Nash equilibrium and lead to complex dynamics, including chaos. Finally, a control mechanism is introduced to restore stability.

Keywords: Discrete dynamical system, Heterogeneous expectations, Stability, Control chaos, Generalized profits, R&D

Influence of the delay on the properties of limit sets of a low-dimensional hydrodynamic system

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Abstract

Non-ideal deterministic system "tank with liquid-electric motor" is studied. Two approaches to study the influence of the delay are proposed. A comparative study of two approaches is presented, and their domains of applicability with respect to the parameter are determined.

The impact of the delay on the emergence, evolution, and disappearance of regular and chaotic limit sets (attractors) of the

system is investigated. Quantitative changes in the value of the delay can lead to qualitative changes in the types of attractors of the system. So, regular attractors can turn into chaotic ones and vice versa. Also, a change in the delay value can lead to the occurrence of new scenarios, both transitions from regular attractors to chaotic ones and transitions from a chaotic attractor of one type to a chaotic attractor of another type. Additionally, the so-called "alternation" of attractors is established.
Keywords: delay, regular attractors, chaotic attractors, limited excitation, scenarios of transition to chaos.

Invariant Model of Boltzmann Statistical Mechanics and Generalized Thermodynamics

Invariant Boltzmann Statistical Mechanics and the Gap Between Classical and Quantum Mechanics

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Abstract

In a series of recent studies, some implications of a scale-invariant model of Boltzmann statistical mechanics [1] to the diverse fields of hydrodynamics, theory of laminar flame, thermodynamics, chaos theory, special theory ofrelativity, quantum mechanics, black hole mechanics, electromagnetism, and statistical theory of turbulence were investigated. Hierarchies of embedded statistical fields and associated invariant conservation equations were found to govern generalized hydrodynamics from photonic to cosmic scale. Identifying physical space as Casimir vacuum resulted in stochastic definitions of Planck and Boltzmann constants (h, k) thus leading to derivation of Schrödinger wave equation from

Bernoulli equation, and Dirac relativistic wave equation from diffusion equation [1]. Stochastic definitions of (h, k) revealed that these universal constants are not fundamental. The fact that amongst (e, c, h), Pla nck constant h may not fundamental was anticipated by Dirac. Physical foundation of both spatial and temporal uncertainty principles will be discussed. Also, some implications of the model to broader ontological and epistemological questions regarding philosophy and unity of science will be addressed.

Since conservation equations of turbulent hydrodynamics were suggested as dissipative deterministic model of quantum gravity by 't Hooft [2], some implications of the model to physical foundations of loop-quantum gravity and string theory will be also examined. In particular, existential connections between energy, density, and scalar curvature are expected to facilitate resolution of both re-normalizability as well as unitarity of theory of quantum gravity. Also, the physical foundation of classical mechanics as well as the connections between classical mechanics and quantum mechanics will be studied. It is shown that both classical as well as quantum mechanics are not closed theories and require modifications as anticipated by Dirac. New scientific paradigms concerning the definition of temperature, heat, work, entropy, internal spacetime, external space and time, mass, etc. will be further described. The physical nature of internal thermodynamic spacetime and external independen t space and time and their connection to Rovelli [3] thermal time and irreversibility (reversibility) of external (internal) time will be further explored.

Keywords: Classical mechanics . Quantum mechanics . Quantum gravity . Quantum cosmology . Balck hole . White hole . Anti-matter . T.O.E.

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The equation of evolution and the physical content of the concept of entropy

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Abstract
The current state of the concept of entropy and the problems of its physical content for dynamic systems are considered. Particular attention is paid to the limitations of the statistical definition of entropy based on the condition of realization of the macrostate of the system by its equally probable microstates. It is shown how these limitations exclude the possibility of using the statistical definition of entropy for studying the evolution of nonequilibrium systems. A brief explanation of the evolution equation is offered [1]. The advantage of this equation is that it allows studying nonequilibrium processes of matter evolution, that is, the processes of emergence, development and decay of systems based on the laws of physics. It is shown how the definition of D-entropy, applicable to description of the processes of evolution of open nonequilibrium dynamic systems (ONDS) follows from the evolution equation [2]. The properties of D-entropy and its physical content are considered. The relationship between the statistical concept of entropy and Clausius entropy with D-entropy, which determines the evolution of ONDS, is shown. The role of Order and Chaos in the construction of classical mechanics and thermodynamics is discussed. The relationship between the concepts of Chaos and Order and the internal energy and energy of motion of a system

is examined, and their physical essence is defined. The place of D-entropy in the nature of the relationship between Order and Chaos for ONDS is demonstrated. Based on the concepts of Order and Chaos, an explanation of the physical nature of the second law of thermodynamics is proposed, and the connection of this explanation with evolution is demonstrated. Phenomenological and statistical methods for constructing thermodynamics are discussed [3]. The possibility of constructing it within the framework of the fundamental laws of physics based on the evolution equation is demonstrated, and methods for such a construction are proposed, relying on the key parameters of classical mechanics..

Keywords: entropy, energy, irreversibility, evolution, mechanics, thermodynamics, chaos.

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Lyapunov Integrability Test (LIT): A Numerical Method for Detecting First Integrals in Dynamical Systems

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Abstract

We introduce the Lyapunov Integrability Test (LIT), a numerical method designed to detect first integrals in nonlinear

dynamical systems, with particular emphasis on models depending on external parameters. The key idea is to use Lyapunov exponents not only as indicators of chaos, but also as practical tools for identifying integrable dynamics.

The method is based on systematic scans of parameter space combined with ensembles of initial conditions and accurate numerical computation of the full Lyapunov spectrum. Regions of integrability are detected as those in which all non-negative Lyapunov exponents consistently vanish across the ensemble. This information is visualized using Lyapunov diagrams with logarithmic color scaling, which allows one to clearly distinguish integrable behavior from weak chaos and long transient effects.

We demonstrate the effectiveness of the approach on several representative systems, including the ABC flow, the heavy top, quantum dot models, and the Swinging Atwood machine. In all cases, the LIT efficiently reveals integrable and near-integrable structures in parameter space.

Keywords: Nonlinear dynamics, Chaos, Lyapunov exponents, Integrability.

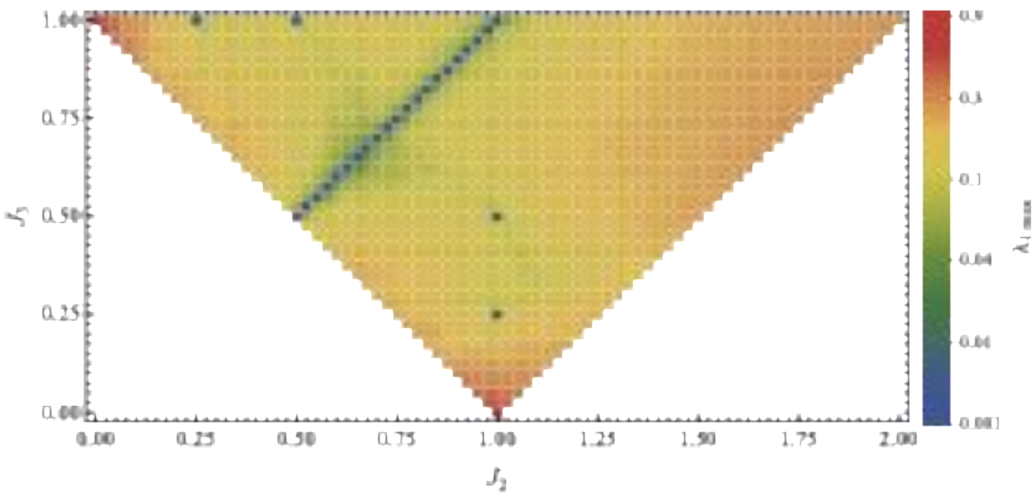

Fig. LIT diagram of the heavy top in the parameter plane - blue rectangles mark integrable cases.

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Ergodic Properties of the Solution of Stochastic Fractional Heat Equation Driven by Fractional Brownian Sheet with Hurst Paremeter

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Abstract
In this work we study the ergodicity with respect to the space variable of the solution of fractional stochastic heat equation driven by fractional Brownian sheet with Hurst parameter H□((1/2,1)^2 and we apply this result to estimate the diffusion parameter.
Keywords: fractional stochastic heat equation, Ergodicity, fractional, Brownian sheet, duffusion parameter estimation, fractional noise.

Application of CFD and Nonlinear dynamics in the analysis of the influence of hyperlipidaemia on the regulation of microcirculation

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Abstract:
Building on our long-term research on vascular microfluidic dynamics, our team developed an algorithm to record and analyze vasomotion in a single blood vessel within the microcirculatory bed. After subsequent Fourier and wavelet analyses, we identified four frequency intervals via frequency-amplitude separation.
Arterioles between 45 and 80 mkm in diameter were measured. Spectral range of oscillations with physiological relevance is found, from 0.0095 to 1.2 Hz, and four subintervals are revealed: (0.0095-0.02 Hz), (0.02-0.05 Hz), (0.05-0.14 Hz), and (0.14-1.2 Hz), by wavelet analysis. In this work, our group applied the wavelet Daubechies analysis. Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform.
Using the CFD-module COMSOL-Multiphysics (COMSOL Ltd.), our team created a simulation of changes in blood pressure at normal levels of blood viscosity and under conditions of artificially induced hyperlipidemia.
Changes in blood pressure were monitored using an implant.
The 2.0ccXS implantable transmitter (TSE-Stellar Telemetry Ltd.) is designed to measure blood pressure (BP) and activity in freely moving laboratory mice. The fluid-filled catheter is placed in the free-flowing blood of the systemic artery (inserted into the left carotid artery and extended into the aorta), and the transmitter body is placed in a benign location for long-term biocompatibility. The transmitter can be used to monitor BP in mice (as small as 17 g) under normal physiological and unrestricted conditions, 24 h a day, while avoiding stress associated with human interaction.
Microfluidic dynamics simulations show that hyperlipidemia-induced increases in plasma viscosity disrupt the

hemodynamics of the capillary network, changing it from a relatively ordered state to one characterized by non-stochasticity—or increased, unpredictable, and inefficient variability in blood flow. This phenomenon is due to increased viscosity, which, instead of acting uniformly, induces segment-specific remodeling, reduced capillary perfusion, and impaired endothelial shear sensing.
This study directly demonstrates that increased plasma viscosity alters microcirculatory dynamics by slowing capillary blood flow, suppressing pressure-induced tone, and increasing endothelial share/stress.

Keywords: CFD, Non-linear dynamic flow, hyperlipidaemia, Blood pressure, Simulation

Existence of Solutions to a Hadamard Fractional Boundary Value Problem at Resonance

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Abstract
We investigate the existence of solutions for a Hadamard fractional differential equation, subject to nonlocal boundary conditions which contain Hadamard fractional derivatives and Riemann-Stieltjes integrals. This problem is a resonant one in the sense that the corresponding homogeneous boundary value problem has nontrivial solutions. In the proof of the main result we use the Mawhin continuation theorem.
Keywords: Hadamard fractional differential equation, nonlocal boundary conditions, resonant problem, existence.

A Statistical Mechanics Model of the Crown Flash Phenomenon

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Abstract

By synthesizing ferrofluid experimentation with the principles of statistical mechanics and the dynamics of chaotic systems, we investigate the "jumping sundog" or “Crown Flash” phenomenon through the lens of ice crystal dynamics. We hypothesize that ice crystals function as microscopic dipolar needles that undergo phase transitions driven by temperature and atmospheric electric fields. In this model, crystals maintain a specific alignment below a critical temperature, transitioning to a disordered state once that threshold is exceeded. Rapid fluctuations in cloud-based electric fields, potentially triggered by internal charge shifts or sub-visual lightning, disrupt this order, manifesting as the characteristic "whip-like" motion of the sundog. This temperature-dependent behavior suggests a memory effect (hysteresis) and indicates that jumping sundogs are a critical phenomenon where minute environmental shifts catalyze macro-scale changes in crystal orientation, as it is shown in figure below.

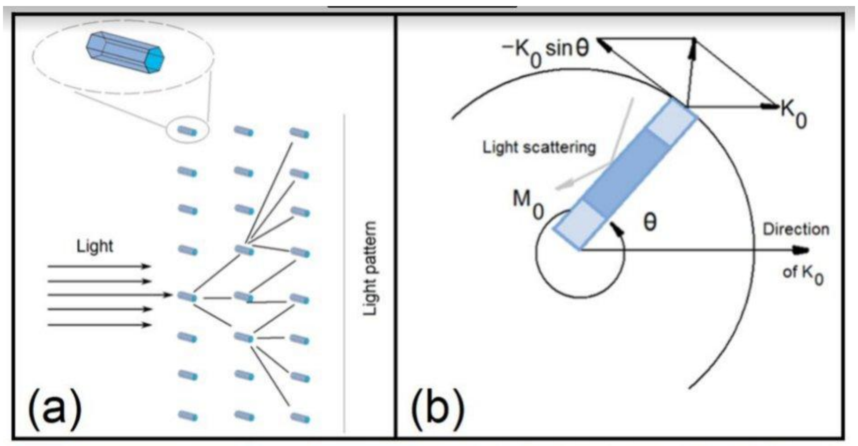

Figure (a) shows ice crystals oriented by electric fields and aerodynamics scattering the light. Figure (b) displays a rigid rotor model for each crystal.

Keywords: Chaotic modeling, Crown Flash, Ferrofluids, Ising Model, Hysteresis.

Feedback Stabilization Applied to Heart Rhythm Dynamics Using an Integro-Differential Method

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Abstract
In this paper, we applied a chaos control method based on integro-differential equations for stabilization of an unstable cardiac rhythm, which is described by a variation of the modified Van der Pol equation. Chaos control with this method may be useful for stabilization of irregular heartbeat using a small perturbation. This method differs from other stabilization strategies by the absence of adjustable parameters and the lack of rough approximations in determining control functions whose control parameters are fixed by the properties of the unstable system itself.

Bibliography

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